TIMBER HARVESTING AND LIVESTOCK GRAZING EFFECTS ON DECIDUOUS COMMUNITIES OF THE LOWER FOOTHILLS SUBREGION

Alberta
SUSTAINABLE RESOURCE
DEVELOPMENT

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DISCLAIMER

This report is intended to provide Sustainable Resource Development staff with up-to-date information regarding the effects of summer timber harvesting and domestic livestock grazing on aspen regeneration, plant community composition, and rangeland health.

The recommendations expressed in this report are based on empirical evidence or the collective experience of the authors and do not necessarily reflect the views of the government of Alberta.

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ABSTRACT

Summer harvesting on moist sites with heavy clay soils reduced shrub cover and created a community that was dominated by aspen, fireweed and marsh reedgrass. It is clear that harvesting affects plant community structure and species composition of deciduous forests, even in the absence of grazing. Therefore, in order to assess proper livestock use of regenerating deciduous cutblocks, a modified range health tool had to be developed that could differentiate between harvesting and grazing effects.

The modified health tool that measures plant species utilization, plant species composition, plant community structure, and site disturbance caused by animals was strongly correlated with livestock utilization and regeneration success. Superior health ratings corresponded to higher stem densities of trees and height and volume of individual trees. This study verifies that the modified range health tool can be used to develop a new cutblock assessment tool for assessing grazing impacts relative to forest regeneration on deciduous cutblocks (Hincz et al. 2004).

Grazing use levels are correlated with modified range health and regeneration success. Moderate to heavy livestock use ($\geq$ 40%) reduced aspen stem density, individual tree height and volume and native plant species composition. In contrast light to moderate grazing use (10-35%) increased individual tree height and volumes, achieved regeneration standards and maintained grazing use.

Access greatly influences livestock behaviour. Increased access was strongly correlated with grazing use, rangeland health, and aspen stem height. During the cutblock planning stage, potential livestock access to regenerating blocks before and after harvest operations should be taken into consideration. Additional grazing controls and distribution tools may be needed to manage livestock behaviour when access points to regenerating cutblocks are numerous.

Recommendations for successful deciduous regeneration and long-term grazing use include: 1) timber and grazing operator communicate and plan prior to timber harvest; 2) cutblock layout should be planned to prevent excessive livestock access; 3) winter harvest; 4) defer grazing until aspen suckers harden-off; 5) incorporate a light to moderate grazing regime.

INTRODUCTION

Traditionally, the Alberta government has issued grazing dispositions within aspen dominated, forest communities to provide livestock producers with an economical source of summer forage. Until relatively recently aspen was not considered to be merchantable timber. The frequency of timber-range resource conflicts has increased coinciding with aspen becoming a merchantable timber species and the subsequent issuance of deciduous timber licenses and Forest Management Agreement (FMA) areas. Consequently, the lands now allocated under FMAs are subject to continuous demand from local livestock producers for new grazing opportunities. Timber-range resource conflicts have become more apparent as the use of aspen stands for both cattle and timber industries increased. Conflict between the two user groups arose from their narrowly focused objectives and each industry's tendency to plan and operate in isolation. Forestry objectives focused on tree harvest and successful regeneration, while cattle producers required an economically viable and long-term source of forage for summer grazing. Lack of appreciation for differing objectives and the reluctance to apply multiple use (forestry) and proper use (grazing) principles contributed to the resource-based conflicts (Nordstrom 1984). It became apparent that a broader approach was needed to incorporate both industry's management principles and objectives. Managing for sustainable resources required an integrated approach between users with an understanding of forest ecology, and the complex interaction of timber, forage and cattle (Nordstrom 1984). Stakeholder committees were formed and the "Guidelines for Integrating Timber Harvesting and Domestic Grazing" were developed to outline an integrated process for reducing these resource conflicts.

At the operational level, recent work by Lane (1998) found that 16% of summer harvested cutblocks had problems regenerating aspen because of increased decking and skidding disturbance. Dockrill (2001) found that continuous June-July grazing by livestock impeded aspen regeneration. Therefore, the combination of summer harvesting and intense early summer grazing has a significant impact on aspen regeneration and longer-term timber productivity. Young emerging aspen suckers have a high protein content (Lane and Willoughby 2000) and are selectively grazed early in the growing season relative to alternative forage i.e., marsh reedgrass. Emerging aspen suckers are also more vulnerable to loss or damage versus more mature stems that lignify later in the growing season and become less palatable to livestock.

Despite these recent studies the complex interaction between livestock grazing patterns and timber harvesting and the combined effect of livestock grazing and timber harvesting on the successional sequence of regenerating deciduous communities are not clearly understood. The objectives of this paper are to:

- outline the successional changes of harvested deciduous communities under different grazing and harvesting regimes;
- test and verify the modified rangeland health assessment tool;
- determine the effect of access created by timber harvesting, oil and gas development, water, and salting on livestock use and subsequently to rangeland health, and tree regeneration.

Site description

The experimental area was located 15 miles north of Nojack, Alberta within the Lower Foothills subregion. This subregion represents the transition between the Rocky Mountains to the west and the boreal forest to the north and east of the study area. Prior to harvesting the area was dominated by Aspen (Aw)-Balsam Poplar (Pb)/Alder/Marsh reedgrass forests situated on mesic sites (Lane et al. 2000).

Timber harvesting methods included clear-cutting with full tree skidding in alternating cut and leave blocks on a two pass harvest plan (Lane 1998).

Methods

Experimental design

Four cutblocks were harvested during the summer and fall of 1994. Two blocks were harvested during July and two blocks were harvested in late August. The July harvested blocks were grazed by livestock only in June and July (J-J) and the August harvested cutblocks were grazed only in August and September (A-S) for seven years from 1995 until 2001. Three 50 m x 100 m exclosures were established in the two grazing treatments. Paired 30 meter transects were established at each exclosure site. One transect was located on the inside of the exclosure (ungrazed by livestock) and the other transect was located on the outside of the exclosure (grazed by livestock). The canopy cover (%) of each plant species was recorded at two meter intervals along each transect. The canopy cover of forbs and grass were recorded in a 20 cm x 50 cm quadrat and the canopy cover of shrubs and trees were recorded in a 1 m^2 quadrat.

Plant community classification

The plant species data for each transect were analyzed using the multivariate analysis techniques of classification and ordination. Classification is the assignment of samples to classes or groups based on the similarity of species. A polythetic agglomerative approach was used to group the samples. This technique assigns each sample to a cluster that has a single measure. It then agglomerates these clusters into a hierarchy of larger and larger clusters until finally a single cluster contains all the samples (Gauch 1982). Cluster analysis was performed in SAS and Euclidean distance was used as the Cluster Distance Measure and Ward's method was used in the Group Linkage Method. The groupings generated in cluster analysis were overlain on the site ordination to determine final groupings. Ordination was used to find relationships among species, communities and environmental variables. Ordination reduces the dimensionality of the data to 1-3 most important axes to which environmental gradients can be assigned. The ordination technique used in the analysis of the data was DECORANA (Detrended Correspondence Analysis). DECORANA detrends and rescales the axes thereby reducing the arching and compression of axes problems associated with other ordination techniques (Reciprocal averaging, Principle Components Analysis). Once final groupings were determined on the ordination specific environmental variables can be assigned to the variation outlined on the ordination axes.

Plant community type summaries were generated in SAS by averaging plant species composition, range in composition and percent constancy of occurrence among groups of vegetation inventory plots that were part of a community type.

Rangeland Health Assessments

Range health is measured by comparing the functioning of ecological processes on an area of rangeland to a standard known as an ecological site description. An ecological site is similar to the concept of a range site, but a broader list of site characteristics are described. An ecological site is defined by the Task Group on Unity and Concepts (1995) as, " *a distinctive kind of land with specific physical characteristics that differs from other kinds of land in its ability to produce a distinctive kind and amount of vegetation*". We use range health to indicate the ability of rangeland to perform certain ecological functions. The functions include: net primary production, maintenance of soil/site stability, capture and beneficial release of water, nutrient and energy cycling and plant species functional diversity. A range health assessment expresses the health of the plant community in comparison to the reference plant community (RPC). For a detailed description on how to assess rangeland health for various plant communities please refer to "*Rangeland Health Assessment for Grassland, Forest and Tame Pasture*" (Adams et al. 2003). Forest harvesting practices can greatly affect these health parameters often causing the range health score to be very low. Consequently, a modified rangeland health rating was used and included the following parameters for assessing livestock impacts: **1. Plant species utilization** – This parameter evaluates livestock and wildlife utilization of the understory and tree plant species. **2. Plant species composition** - Plant species composition is a key indicator of block utilization. A high cover of grazing resistant species will indicate a site that has been heavily utilized. **3. Plant Species Structure** – Obviously harvesting has an impact on plant community structure. Overstory trees, tall shrubs and bryophytes are all heavily impacted by harvesting disturbance. When examining this parameter understory trees, low shrubs and a diversity of native forbs and grasses should be present. **4. Physical Animal Site Disturbance** – Accelerated erosion due to human management activities is a serious issue, leading to long-term negative impacts on the site potential. This parameter looks at increased soil erosion caused by livestock and wildlife activity **5. Litter and Carryover** – Litter acts as a physical barrier to heat and water flow at the soil surface. The lack of litter on the soil surface compared to the site potential can be an indicator that the area is being disturbed.

Livestock distribution and utilization patterns

Prior to harvesting in 1994, livestock use of pipelines, well sites and forested community types was determined by clipping forage production on the inside and outside of forage production cages. The difference in forage production between the inside and outside was estimated as a percentage. Livestock use on every grazed transect outside the exclosures was also estimated in a similar manner from 1995 until 2001. In 2002 and 2003 livestock utilization was also estimated on a grid of points located every 500 meters throughout the two grazing treatments. Grid points fell within forests, cutblocks, pipelines and well sites. At each grid point livestock utilization and a range health

assessment were done. If the grid point fell within a cutblock a modified rangeland health assessment form was completed.

An arcview-based coverage map, including satellite imagery, was used to create an access index for each cutblock. The index was created by measuring the distance of the central point within the cutblock to access features surrounding the cutblock. These features included roads, cutlines, pipelines, well sites, salt and water locations. Each access feature was scaled (from 0.0 to 1.0, with 0 the least and 1.0 the most accessible) based on the effect of a given access feature on livestock behaviour and distribution i.e., cutline 0.6, permanent road 1.0, wellsite 0.8, pipeline 0.9, water and salt 1.0. It is important to note that these access feature values may vary depending on differences between sites and livestock behaviour. Each access feature ranking was divided by the distance (meters) from the cutblock central point, summed, multiplied by 100 and rounded to the nearest whole number. The higher the access index for a cutblock the greater the amount of potential livestock accessibility. The access index was calculated for each cutblock within the study area and related to grazing use, modified range health, and tree regeneration. A simple linear regression was used to test for relationships between access, rangeland health, percent utilization, tree density and tree height.

Regeneration surveys

Establishment regeneration surveys of each cutblock within the two grazing treatments were performed by Weyerhauser in 1998 following the procedure outlined in the Alberta Regeneration Survey Manual (2003). Additional regeneration plots were conducted along a 500m x 500m grid for the entire study area; regeneration plots were done at each grid point if it fell within a cutblock. Regeneration plots were also done every two meters along each permanent transect within each permanent exclosure.

RESULTS

Plant community succession

Harvesting

Table 1 outlines the plant successional changes from 1995 to 2000 from the cutblocks harvested in July (summer) and the blocks harvested in late August (fall) of 1994. Shrub cover, especially green alder, appears to be reduced by summer harvesting relative to fall harvesting and pre-harvest shrub cover. In contrast marsh reedgrass appears to be initially suppressed in the fall harvested blocks, but recovered to pre-harvest levels after 7 years. Summer harvesting appears to stimulate the growth of marsh reedgrass. Seven years after summer harvesting the canopy cover of marsh reedgrass in the cutblocks continues to exceed the cover in the unharvested forest. Aspen and balsam poplar cover are near pre-harvest levels in the summer and fall harvested blocks and tree species stem density of deciduous trees in harvested blocks is nearly 3 times greater than in the unharvested forest.

Grazing

The ordination of the August-September (A-S) and June-July (J-J) grazed transects with years (e.g., AS99) and blocks (e.g., AS991) grouped by cluster analysis are outlined in Figure 1. The first two axes in the ordination account for 50% and 9% of the

variation in the species stand table, respectively. There is a distinct grouping of the grazed transects in the June-July treatment block 1 from 1996 until 2001 and the June-July grazed treatments in block 2 and 3 in the years 2000 and 2001 (Dandelion-Clover/Kentucky bluegrass (**1**)), the grazed June-July transects in blocks 2 and 3 from 1995 to 1999 and the 1995 block 1 transect (Aw/Rose/Strawberry-Clover (**2**)) and finally all of the August-September grazed transects from 1995-2000 (Aw-Pb/Rose/Marsh reedgrass (**3**)). The first axis in the ordination appears to account for a grazing gradient. The group on the right hand side of axis 1 represents a plant community type that has been heavily grazed. Average utilization on transects in this group was 74% and varied from 40-90% (Table 2). This community is dominated by grazing resistant species of dandelion, clover and Kentucky bluegrass (Table 2). Aspen and balsam poplar cover are significantly reduced compared to the other transects found on the left hand side of axis 1. In contrast, transects found on the left hand side of axis 1 (group 3) represent transects that appear to have be lightly grazed. Average utilization on these transects was 22% and varied from 10-35% (Table 2). This plant community tends to be dominated by native species, fireweed and marsh reedgrass and has significantly higher cover of both aspen and balsam poplar compared to the heavily grazed community type. The plant community in the middle of axis one (group 2) appears to represent a community that has been moderately grazed. Average utilization was 54% and varied from 40-90% (Table 2). This community was generally dominated by native species, i.e. strawberry, rose, aspen and marsh reedgrass, but there was slightly higher cover of more grazing resistant species (clover) when compared to group 3. Tree canopy cover was also significantly reduced in this community compared to the lightly grazed community on the left hand side of axis 1 (Table 2).

It appears that preharvest deciduous communities that were already heavily impacted by livestock continued to be preferred by livestock even after harvesting. For example it took only one year of heavy grazing before replication 1 in the June-July grazing treatment (JJ951o to JJ961o) changed from an Aw/Rose/Strawberry-Clover dominated community to a Dandelion-Clover/Kentucky bluegrass dominated community (Figure 2). In contrast the other two replications in the June-July grazed treatments did not succeed to the Dandelion-Clover/Kentucky bluegrass dominated community until they had been moderately to heavily grazed for 5 years. Prior to harvesting this deciduous community adjacent to replication 1 had been heavily impacted by livestock grazing and the understory already had a significant cover of dandelion, clover and Kentucky bluegrass. Once harvesting occurred, livestock continued to use the site heavily and the understory species composition quickly became dominated by these grazing resistant species.

Table 1. Successional changes of selected species (%) on summer and fall harvested deciduous cutblocks in the absence of grazing from 1995 to 2000 compared to an unharvested forest.

		Summer			Fall		
Species	Unharvested	1995	1998	2000	1995	1998	2000
Trees							
Aspen *(Populus tremuloides)*	20	4	10	24	9	10	25
BALSAM POPLAR (*Populus balsamifera*)	17	1	1	2	2	6	17
Shrubs							
GREEN ALDER (*Alnus crispa*)	36	1	2	2	1	9	15
ROSE (*Rosa acicularis*)	11	5	2	5	9	3	4
LOW BUSH CRANBERRY (*Viburnum edule*)	4	1	1	2	2	1	4
Forbs							
FIREWEED (*Epilobium angustifolium*)	5	1	3	5	5	6	12
WILD SARSAPARILLA (*Aralia nudicaulis*)	8	2	1	1	2	3	1
HEART LEAVED ARNICA (*Arnica cordifolia*)	1	1	1	1	3	3	6
YELLOW PEAVINE (*Lathyrus ochroleucus*)	2	1	1	1	2	1	2
STRAWBERRY (*Fragaria virginiana*)	4	7	5	3	3	3	4
LINDLEY'S ASTER (*Aster ciliolatus*)	4	3	2	3	3	2	2
Grass							
MARSH REEDGRASS (*Calamagrostis canadensis*)	23	23	41	32	6	18	27
Deciduous trees (Stems/Ha)	~ 750	48000	35000	17500	47000	38000	17200

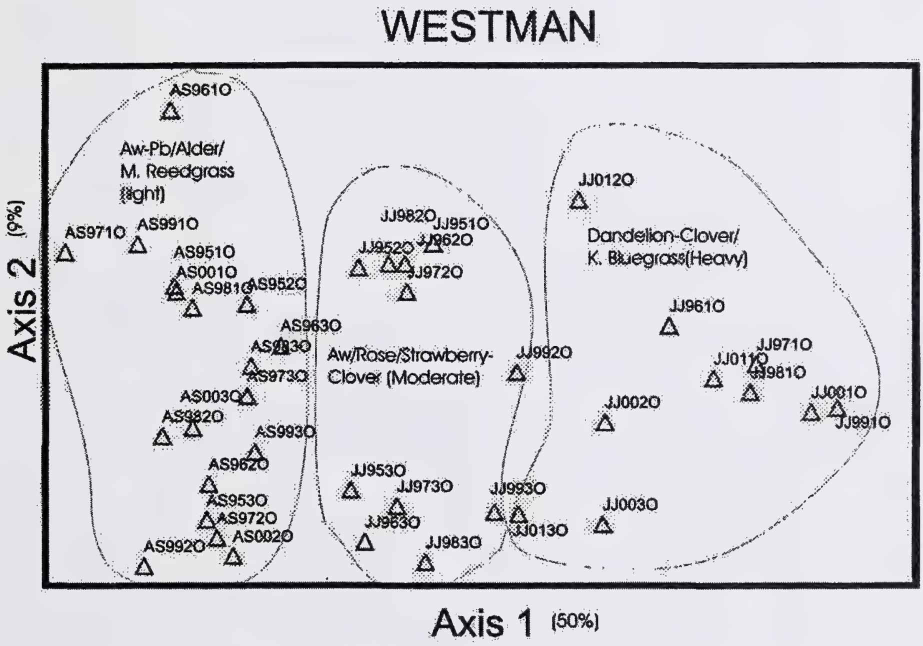


Figure 1. Ordination of June-July and August-September grazed treatments on deciduous cutblocks of the Lower Foothills subregion.

Table 2. Change in species canopy cover (%), utilization and range health ratings on deciduous cutblocks under light, moderate and heavy grazing regimes over 7 years in the Lower Foothills subregion.

Species	Aw-Pb/Alder /Fireweed/Marsh reedgrass (Light)	Aw/Rose/ Strawberry-Clover (Moderate)	Dandelion-Clover/ Kentucky bluegrass (Heavy)
Trees			
Aspen *(Populus tremuloides)*	5a	4b	2b
BALSAM POPLAR (*Populus balsamifera*)	7a	1b	0b
Shrubs			
GREEN ALDER (*Alnus crispa*)	5a	2ab	1b
ROSE (*Rosa acicularis*)	5b	11a	7ab
Forbs			
FIREWEED (*Epilobium angustifolium*)	8a	2b	1b
DANDELION (*Taraxacum officinale*)	1b	1b	7a
WILD SARSAPARILLA (*Aralia nudicaulis*)	2a	1a	Tb
STRAWBERRY (*Fragaria virginiana*)	8a	11a	8a
DEWBERRY (*Rubus pubescens*)	4a	3ab	1b
CLOVER (*Trifolium repens*)	1b	3b	23a
Grass			
MARSH REEDGRASS (*Calamagrostis canadensis*)	16a	19a	7b
KENTUCKY BLUEGRASS (*Poa pratensis*)	1b	1b	10a
% utilization	22 (10-35)	54(40-90)	74(40-90)
Modified Range health assessment rating (average%)	Healthy (98%)	Healthy with problems (74%)	Unhealthy (40%)

Note. Means within a row with the same letter are not significantly different according to an LSMEANS test at the 0.05 level

Modified rangeland health

There was a strong correlation between modified health ratings and utilization levels by livestock (Table 2). For example the lightly utilized (22%) Aw-Pb/Alder/Fireweed/Marsh reedgrass community was rated as healthy and had an average modified health rating of 98%. In contrast the heavily utilized (74%) Dandelion-Clover/Kentucky bluegrass community was rated as unhealthy and had an average health rating of 40%. The moderately utilized (54%) Aw/Rose/Strawberry-Clover community was rated as healthy with problems and had an average modified health rating of 74%. These health ratings can be visualized in Figures 2, 3 and 4. Healthy sites are dominated by trees and shrubs, utilization of the understory vegetation is light, plant species composition is mostly native, there is little soil exposure and there is extensive standing and dead litter (Figure 2). In contrast unhealthy sites have few to no trees or shrubs, utilization is heavy, plant species composition is dominated by non-native species, there is soil exposure caused by livestock and there is little standing or dead litter (Figure 4). Healthy with problem sites are in between the two extremes. These sites have trees growing, but the tree density is reduced. Utilization levels are moderate with patches of heavily grazed and ungrazed areas and litter levels are also patchy (Figure 3).

Figure 2. Healthy deciduous cutblock represented by the Aw-Pb/Alder/Fireweed/Marsh reedgrass community type.

Figure 3. Healthy with problems deciduous cutblock represented by an Aw/Rose/Strawberry-Clover community type.


Figure 4. Unhealthy deciduous cutblock represented by the Dandelion-Clover/Kentucky bluegrass community type.

Tree regeneration

Table 3 outlines the regeneration of deciduous trees in grazed and ungrazed areas of the moderate to heavily and light to moderately grazed treatments at eight years post harvest. Clearly, grazing significantly reduced stem density in the grazed areas of both grazing treatments. The moderate to heavily grazed treatment also significantly reduced the height and volume of individual trees. In contrast height and volume of individual trees were much greater in the grazed areas compared to the ungrazed areas of the light to moderately grazed treatment.

Table 3. Deciduous stem density (stems/ha), height (cm), root collar diameter (mm) and tree volume (cc) for Moderate-Heavily and Light-Moderately grazed and ungrazed treatments 8 years post harvest.

	Moderate-Heavily (40-90%)				Light-Moderately (10-35%)			
Treatment	St/ha	Ht	rcd[1]	Vol.[2]	St/ha	Ht	rcd	Vol.
Grazed	5800b	135b	18b	173b	10400b	443a	50a	3123a
Ungrazed	17500a	386a	41a	1816a	17200a	431a	43b	2175b

Means with the same letter are not significantly different according to an SNK test at the ($p>0.05$ level)
[1]rcd = root collar diameter
[2]Vol. = individual deciduous tree volume

When range health ratings are compared to deciduous regeneration across all cutblocks within the two grazing treatments there is a strong relationship between increased cutblock health, decreased grazing use, and increased regeneration success. Healthy cutblocks (75-100%) generally have greater tree density, tree height and volume, whereas, cutblocks rated as unhealthy (<50%) have reduced stem density, height and volume (Table 4).

Harvesting and Livestock Distribution

Grazing use patterns

Grazing use patterns changed following harvesting within the study area. Preharvest mature aspen stands were grazed at 28% with well sites and pipelines grazed at 80 to 90% use. Post harvest utilization levels were maintained on well sites and pipelines but grazing on aspen cutblocks and mature stands showed an overall 7% increase in livestock use. Use patterns showed little change between one and eight years post harvest; however, there appears to be a greater livestock preference for cutblocks in june-july versus august-september when compared to aspen forest.

Cutblock access

Table 4 illustrates the relationship between individual cutblock access features (i.e., the cumulative effect of access created from roads, wellsites, pipelines, seismic lines, cattle trails, and salting and watering sites), and grazing use, rangeland health and deciduous regeneration. There is a significant linear relationship between increased access and increased grazing use, decreased rangeland health, and decreased deciduous tree height. There is no significant relationship between access and tree density.

Overall cutblock regeneration success is measured by regeneration survey results (NSR, or SR) rather than individual tree regeneration response variables. Table 4 and Figure 5

attempt to relate access index to overall cutblock regeneration success. Access index < 3.0 have successfully regenerated. Overall results indicate that access features (<3.0), grazing use (light to moderate), and modified rangeland health (avg. healthy 86%) are useful indicators of deciduous regeneration success (+8000 stems/ha, +400 cm stem height, and SR cutblocks).

Table 4. Relating cutblock access to grazing use, range health, and deciduous regeneration at 8 years post-harvest.

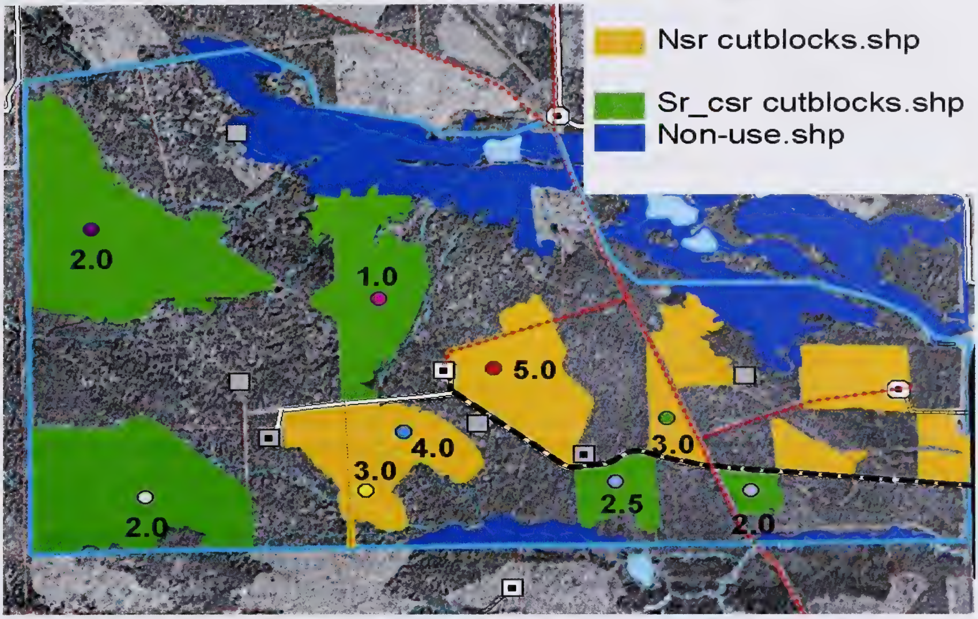
Cutblock Access Index	Grazing Use (%)	Modified Rangeland Health (%)	Deciduous Regeneration* Density (Stems/ha)	Height (cm)	Regeneration Survey**
5.0	75	35	1200	46	NSR
4.0	65	55	7700	160	NSR
3.0	40	55	9400	126	NSR
3.0	75	69	2000	18	NSR
2.5	30	N/A	N/A	N/A	SR
2.0	47	75	8100	377	SR
2.0	29	86	8700	410	SR
1.0	17	97	8000	400	SR
Correlation***	R^2=.63 $p>0.05$	R^2=.91 $p>0.05$	R^2=.23 $p=0.15$	R^2=.57 $p>0.05$	

* 2002 and 2003 Range Survey results

** Weyerhaeuser – Edson Regeneration Survey results [Not Satisfactorily Restocked (NSR), Conditionally Restocked (CR), and Satisfactorily Restocked (SR).

*** R^2 Significant linear relationship between cutblock access index and grazing use, modified range health and tree height at the $p> 0.05$ level.

Figure 5. Spatial representation of cutblock access index to regeneration success within the study area.



DISCUSSION

Plant community succession

Harvesting effects

Alder cover appears to be reduced by summer harvesting relative to fall harvesting, but season of harvest had little effect on stem density of deciduous trees. This is somewhat surprising because Bates et al. (1990) and Navratil (1991) all found that summer harvesting when conditions are moist can have a significant impact on stem density. Aspen and balsam poplar regenerate quickly from shallow root systems that can be heavily impacted by harvesting when the shallow root systems are compacted by machinery. Lane (1998) found that 16% of all cutblock areas had failed regenerating trees because of the disturbance on roads and landings. Lane also found that tree regeneration was reduced on heavily skidded areas. Climatic, soil and aspen stand conditions indicate winter harvesting is likely the best option for aspen regeneration on summer grazing areas. Winter harvesting will protect the soil-rooting medium, required for natural regeneration, because the soils are frozen. Furthermore, winter harvesting will not disrupt summer grazing operations for livestock (Lane 1998).

Unfortunately, our present native forest range health assessment was not developed to deal with harvested forested stands. In the native forest health assessment scoring is determined based on: 1. The Integrity and Ecological Status, what kinds of plants were found on the site and what was the plant community 2. Plant community structure, are the expected plant layers present or have there been changes in the forest plant community structure 3. Hydrologic Function and Nutrient Cycling, what is the thickness of the Litter Layer (LFH) 4. Site Stability, is there evidence of accelerated erosion and 5. Noxious Weeds, are noxious weeds present on the site and what densities

are the infestations (Adams et al. 2003). Forest harvesting practices can greatly affect these health parameters and therefore a forested range health assessment of a cutblock cannot be directly linked to livestock utilization levels. Harvested sites quickly become dominated by fireweed, marsh reedgrass and regenerating trees (Table 1). Shrub cover and litter are greatly reduced in the first years after harvest. There is also often an increase in bare soil and there can be an increase in noxious weed cover. This makes it extremely difficult to use the forest health assessments on regenerating cutblocks and a modified health assessment tool had to be used.

Grazing effects

Species composition

Moderate to heavy livestock grazing had a negative impact on plant species composition and tree canopy cover. Canopy cover of regenerating trees, tall growing forbs (fireweed, wild sarsaparilla) and marsh reedgrass were all significantly lower in the heavily grazed treatments and cover of grazing resistant species of clover, dandelion and Kentucky bluegrass were much higher in this treatment (Figure 4). Willoughby (1995) and Lane et al (2000) found similar changes in plant species composition in heavily grazed unharvested and harvested deciduous communities in the Lower Foothills subregion. Heavy grazing of an aspen/rose-low bush cranberry/tall forb community will lead to a community that is dominated by aspen, Kentucky bluegrass and clover. In contrast if the site is left undisturbed it will eventually succeed to a white spruce dominated forest. Harvesting of the undisturbed forest communities will lead to a community dominated by fireweed and marsh reedgrass and heavy grazing of this harvested community will lead to the development of a Kentucky bluegrass, clover, dandelion dominated community type (Ecological Site Description Database 2004).

Unharvested deciduous communities that were already heavily impacted by livestock (Kentucky bluegrass, clover, dandelion dominated) continued to be preferred by livestock even after harvesting. The deciduous communities that were adjacent to well sites, and salt and water locations continued to be impacted by livestock after harvesting. This has implications for timber industry efforts to regenerate trees on existing grazing dispositions. Preharvest deciduous communities that exhibit signs of heavy grazing pressure likely will not successfully regenerate trees unless the livestock management of the disposition is changed. A preharvest assessment of the grazing disposition should be done in order to identify areas that may not successfully regenerate trees because of heavy livestock use. This information can then be used to develop management prescriptions for harvesting and livestock distribution.

Tree regeneration

Despite the significant reduction in tree density in the light to moderately grazed treatments compared to the ungrazed control (Table 3), these cutblocks continue to exceed regeneration standards for a performance survey at 8 years (Regeneration Survey Manual 2003). The minimum performance survey standard is 80% stocking (approximate average 7500 trees/ha) at a height of 250 cm. The density of trees in this grazing treatment was over 10,000 stems/ha and tree height exceeded 400 cm. Tree

height and volume in this light to moderate grazing treatment was actually significantly greater than the ungrazed control. Wheeler and Willoughby (1993) and Sundquist (1995) also found similar results on 5-year old cutblocks near Grande Prairie. This implies that light to moderate grazing pressure could improve individual crop tree performance, thereby producing merchantable volume sooner. However, these studies did not extend these trends to stand level volumes so it is not clear if the stand could be harvested sooner. There is also concern that thinning of deciduous regeneration by livestock may increase the risk of disease, however Dale et al. (2001) found no significant difference on the incidents of disease and stain between grazed and ungrazed stands of merchantable Aspen in Alberta. Using livestock to thin regenerating deciduous communities may be a tool that can be used to reduce the time between harvesting rotations, but a long-term study of this under proper grazing management will be difficult.

Modified rangeland health

The modified range health rating system which is the basis for the new rangeland cutblock assessment tool (Hincz et al. 2004) that measures plant species utilization, plant species composition, plant species structure, site disturbance caused by animals and the amount of litter and carryover left after livestock use was strongly related with regeneration success (Table 4). The higher the modified health rating, the higher the density, and the greater the height and volume of individual trees. This is encouraging because both industries now have a tool that can be used to assess livestock use of deciduous cutblocks. Further testing of this new cutblock assessment tool will have to be conducted to evaluate its application to harvested coniferous communities and deciduous communities in other subregions.

Harvesting and Livestock Distribution

Grazing Use Patterns

Grazing use patterns are drastically affected by timber harvesting, therefore harvesting schedules and cutblock configuration must take into consideration traditional and potential livestock distribution patterns and access points in their design. High grazing use (avg. 65%) resulted in a poor deciduous regeneration response (avg. 5000 stems/ha at 87 cm, and NSR cutblocks), whereas light to moderate use (avg. 30%) resulted in greater regeneration response (avg. 8300 stems/ha at 400 cm, and SR cutblocks). Livestock utilization of cutblocks is largely influenced by access, therefore, to ensure a successful regeneration response, livestock access to cutblocks should be managed to achieve light to moderate levels of grazing.

Cutblock Access

Cutblock access is a useful indicator of grazing use, range health, and potentially cutblock regeneration success. Despite being a relatively non-scientific approach to predicting livestock behaviour, the access index is a simple tool for assessing whether additional livestock access controls need to be applied to maintain a light to moderate grazing regime in regenerating blocks. However, before access values are strictly applied more empirical evidence is needed.

Recommendations towards successful regeneration and long-term grazing use of deciduous forests

The following points summarize the key management recommendations based on empirical evidence and the collective experience of the authors:

- Forest operator and grazing operator must communicate and plan operations together; it is recommended that any agreements be documented and signed-off by both parties prior to harvesting.
- Rangeland health can be used prior to harvesting to determine potential regeneration response. If preharvest aspen forests are unhealthy (due to overgrazing) then regeneration may not be optimal and additional measures may need to be taken to improve stand development.
- Need to assess harvest sequence and cutblock layout for potential livestock access; if blocks are planned in areas of high traditional livestock use, grazing levels may be too high regardless of cattle stocking rates.
    - Cutblock access should be planned prior to harvest for location, configuration, and scheduling to limit livestock access features.
    - Where potential livestock access remains high additional livestock distribution management tools should be applied e.g., salting, watering, and temporary fencing.
- Winter harvesting is recommended, unless the goal is to improve livestock access to cutblocks where tree regeneration becomes a barrier; summer harvesting has been shown to reduce deciduous regeneration (Lane 1998), reduce native plant species composition, and it disrupts summer livestock grazing schedules.
- Post-harvest, defer grazing until aspen suckers hardened-off (Lane 1998, and Dockrill 2001) and are successfully established throughout the cutblock area.
- Stocking rates and grazing use should be based on the preharvest mature forest community with a light to moderate grazing regime (20-30% of total pre-harvest production).
- Monitor grazing use and modified rangeland health as indicators of grazing impact on regeneration success and adjust as formal forest-grazing management agreements as necessary.
- Continued applied research and monitoring is needed to further investigate livestock behaviour in relation to access features and the subsequent impact of grazing intensity on long-term forest productivity.

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